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Founding — Ausferritic spheroidal graphite cast irons — Classification

Fonderie — Fontes ausferritiques à graphite sphéroïdal — Classification

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 25, *Cast irons and pig irons*.

This second edition cancels and replaces the first edition (ISO 17804:2005), which has been technically revised. The main changes compared with the previous edition are as follows:

a) the normative references have been updated;

b) the terms and definitions have been improved and supplemented;

c) a side-by-side cast sample has been included;

d) the method of manufacturing has been made more detailed (including pouring/heat treatment);

e) a subclause (9.4) for graphite structure examination has been added;

f) in Annex C (formerly Annex B), a new conversion table for tensile test results has been added;

g) in Annex H (formerly Annex G), new fatigue data have been added for five different test methods from an international survey;

h) in Annex I (formerly Annex H), nodularity has been made more detailed, in accordance with ISO 945-4[2];

i) the previous Annex I on machinability has been deleted as it is no longer necessary;

j) in Annex J, Chinese GB/T grades have been added and several other international grade changes have been made;

k) the Bibliography has been revised.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Ausferritic spheroidal graphite cast iron is a cast alloy, iron, carbon and silicon based, carbon primarily in the form of spheroidal graphite particles.

Compared to the spheroidal graphite cast iron grades (see ISO 1083[3]), four material grades combine high strength, ductility and toughness properties while two grades combine higher strength with wear resistance as a result of ausferrite matrix structures.

This document deals with the classification of ausferritic spheroidal graphite cast irons in accordance with the mechanical properties of the material.

The mechanical properties of these ausferritic spheroidal graphite cast irons depend on their structure, e.g. the form of the graphite and the structure of the matrix.

The required structure is developed by selecting the appropriate composition and subsequent processing.

The mechanical properties of the material can be evaluated on machined test pieces prepared from:

— separately cast samples with an appropriate gating system, able to provide metallurgical conditions similar to those of the castings they represent;

— samples cast in the mould alongside the casting, with a joint running system, hereafter called "side-by-side cast samples";

— samples cast onto either the casting or the running system, hereafter referred to as "cast-on samples";

— samples cut from a casting (only by agreement between the manufacturer and the purchaser, the agreement specifying, in particular, the conditions of sampling and the values to be obtained).

Two grades of ausferritic spheroidal graphite cast iron are specified in Annex A, in accordance with their hardness. These cast irons are used in applications where high abrasion resistance is required (e.g. mining, earth moving and manufacturing industries).

Five grades of ausferritic spheroidal graphite cast iron are specified by the mechanical properties. When, for these grades, hardness is a requirement for the application, Annex D provides the means for determining appropriate hardness ranges.

Some ausferritic spheroidal graphite cast iron grades can be used for pressure equipment.

Founding — Ausferritic spheroidal graphite cast irons — Classification

1 Scope

This document defines the grades and the corresponding requirements for ausferritic spheroidal graphite cast irons.

This document specifies five grades of ausferritic spheroidal graphite cast iron by a classification based on mechanical properties determined on machined test pieces prepared from:

— separately cast samples, side-by-side cast or cast-on samples;

— samples cut from a casting.

This document also specifies two grades by a classification as a function of hardness.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

ISO 945-1, *Microstructure of cast irons — Part 1: Graphite classification by visual analysis*

ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method*

ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature*

ISO/TR 15931, *Designation system for cast irons and pig irons*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
ausferritic spheroidal graphite cast iron
austempered ductile iron
ADI
cast material, iron, carbon and silicon based, carbon being present mainly in the form of spheroidal graphite particles, subjected to an austempering heat treatment in order to produce an ausferritic matrix

3.2
graphite spheroidizing treatment
process that brings the liquid iron into contact with a substance to produce graphite in the spheroidal form (predominantly form VI) during solidification

3.3
austempering
<spheroidal graphite cast iron> heat treatment process, consisting of heating the castings to a temperature at which austenite starts to form during heating and holding a sufficient time for carbon diffusion into the austenite, followed by cooling at a rate sufficient to avoid the formation of pearlite, and transforming the matrix structure for a time and a temperature (above the martensite start temperature) sufficient to produce the desired properties

Note 1 to entry: This process produces a microstructure that consists predominantly of ferrite and high carbon austenite. This microstructure is called "ausferrite". Examples of ausferritic microstructures are given in ISO/TR 945-3[1].

3.4
ausferrite
cast iron microstructure, produced by a controlled thermal process, which consists of predominantly acicular ferrite and high carbon austenite

3.5
cast sample
quantity of material cast to represent the cast material, including separately cast samples, side-by-side cast samples and cast-on samples

3.6
separately cast sample
sample cast in a separate sand mould under representative manufacturing conditions and material grade

3.7
side-by-side cast sample
sample cast in the mould alongside the casting, with a joint running system

3.8
cast-on sample
sample attached directly to the casting

3.9
relevant wall thickness
section of the casting, agreed between the manufacturer and the purchaser, to which the determined mechanical properties apply

Note 1 to entry: Relevant wall thickness may be associated with a range of casting sections and/or with a sample type and size according to Table 3. The association is made by considering the cooling conditions during solidification and heat treatment.

3.10
test unit
inspection lot
test batch
number of pieces or the tonnage of castings to be accepted or rejected together, on the basis of the tests carried out on the test pieces in accordance with the requirements of the relevant specification, material standard or order

4 Designation

The material shall be designated in accordance with ISO/TR 15931.

Annex J gives a selection of approximate cross-references of grade designations from this document to standard grades from EN, ASTM, JIS, GB/T and SAE standards.

5 Order information

The following information shall be supplied by the purchaser:

a) the complete designation of the material;

b) any special requirements (including the relevant wall thickness, when necessary)

All agreements shall be made between the manufacturer and the purchaser at the time of acceptance of the order.

6 Manufacture

The method of producing ausferritic spheroidal graphite cast iron shall be left to the joint discretion of the foundry and the heat treater.

The chemical composition shall be agreed upon between the manufacturer of the casting and the heat treater.

The method of producing spheroidal graphite cast iron to be austempered shall be left to the discretion of the foundry.

The heat treatment shall be left to the discretion of the heat treater.

Both shall ensure that the casting process and heat treatment process are carried out with the same process parameters as the approved first sample(s).

7 Requirements

7.1 General

The property values of these materials apply to castings cast in sand moulds or moulds of comparable thermal behaviour. Subject to amendments to be agreed upon in the order, they can apply to castings obtained by alternative methods.

The material designation is based on the minimum mechanical properties obtained in separately cast, cast side-by-side or cast-on samples with a thickness or diameter of 25 mm, cast in a sand mould or a mould of comparable thermal behaviour, corresponding to a relevant wall thickness t ≤ 30 mm, as given in Table 1.

For samples cut from the casting, the location shall be agreed between the manufacturer and the purchaser.

The designation is irrespective of the type of cast sample.

Mechanical properties for test pieces cut from a casting are affected not only by material properties (a subject of this document), but also by the local casting soundness (not a subject of this document).

Tensile, impact and any other mechanical testing requires sound material in the test pieces to provide representative test results.

7.2 Test pieces machined from cast samples

7.2.1 General

The mechanical properties of ausferritic spheroidal graphite cast iron grades shall be as specified in Table 1 and, if applicable, in accordance with the requirements given in 7.2.2.

Table 1 — Mechanical properties determined on test pieces machined from separately cast samples, side-by-side cast samples or cast-on samples[4]

Material designation	Relevant wall thickness of the casting t mm	Tensile strength R_m MPa min.	0,2 % proof strength $R_{p0,2}$ MPa min.	Elongation after fracture A_5 % min.
ISO 17804/JS/800-10 ISO 17804/JS/800-10RT	$t \leq 30$	800	500	10
	$30 < t \leq 60$	750		6
	$60 < t \leq 100$	720		5
ISO 17804/JS/900-8	$t \leq 30$	900	600	8
	$30 < t \leq 60$	850		5
	$60 < t \leq 100$	820		4
ISO 17804/JS/1050-6	$t \leq 30$	1 050	700	6
	$30 < t \leq 60$	1 000		4
	$60 < t \leq 100$	970		3
ISO 17804/JS/1200-3	$t \leq 30$	1 200	850	3
	$30 < t \leq 60$	1 170		2
	$60 < t \leq 100$	1 140		1
ISO 17804/JS/1400-1	$t \leq 30$	1 400	1 100	1
	$30 < t \leq 60$	1 170	To be agreed between the manufacturer and the purchaser	
	$60 < t \leq 100$	1 140		

NOTE 1 The properties of castings are not uniform because of the complexity and variation in section thickness.

NOTE 2 With the appropriate heat treatment, the specified minimum 0,2 % proof strength values according to this table can be maintained. However, with increasing casting wall thickness, the tensile strength and elongation values will decrease.

NOTE 3 1 MPa = 1 N/mm^2.

7.2.2 Impact test

The impact energy values given in Table 2 at room temperature, if applicable, shall only be determined if specified by the purchaser at the time of acceptance of the order.

Table 2 — Minimum impact energy values determined on V-notched test pieces machined from separately cast samples, side-by-side cast samples or cast-on samples[4]

Material designation	Relevant wall thickness of the casting t mm	Minimum impact energy value at room temperature (23 ± 5 °C) Mean value of 3 tests J	 Individual value J
ISO 17804/JS/800-10RT	$t \leq 30$	10	9
	$30 < t \leq 60$	9	8
	$60 < t \leq 100$	8	7

7.3 Test pieces machined from samples cut from a casting

If applicable, the manufacturer and the purchaser shall agree on:

— the location(s) on a casting where the sample(s) shall be taken;

— the mechanical properties that shall be determined;

— the minimum values (or allowable range of values) for these mechanical properties (for information, see Annex E).

Tables 1 and 2 may be used for guidance on the likely mechanical properties of the castings. These properties may be equal to or lower than those given in these tables.

7.4 Hardness

Guidance values for the Brinell hardness range of the material grades are given in Annex C.

The grades of abrasion-resistant ausferritic spheroidal graphite cast irons in terms of hardness shall be as specified in Annex A.

7.5 Graphite structure

The graphite structure shall be predominantly of form VI in accordance with ISO 945-1. A more precise definition may be agreed upon at the time of the acceptance of the order.

This structure shall be confirmed by metallographic examination. The technique, visual or image analysis, should be agreed upon at the time of the acceptance of the order.

Additional information regarding nodularity is given in Annex H.

7.6 Matrix structure

Information on matrix structure is given in ISO/TR 945-3:2016, Table 4.6[1].

The matrix structure of the various grades of ausferritic spheroidal graphite cast iron consists predominantly of ferrite and austenite, otherwise known as ausferrite. Other matrix constituents (e.g. martensite, carbides) may be present at a level that will not affect the required mechanical properties.

Intercritical austenitization may be used to produce ISO 17804/JS/800-10 or 800-10/RT. This will result in the formation of a mixed microstructure that includes the presence of proeutectoid ferrite. Intercritical austenitization requires a higher hardenability than the grades specified in Table 1.

The cooling rate within some sections may not be sufficient to avoid the formation of pearlite or other transformation products. In such cases, the maximum acceptable quantities of these microconstituents, the locations within the casting and the mechanical properties in these locations may be agreed upon between the manufacturer and the purchaser.

8 Sampling

8.1 General

Samples shall be provided to represent the castings produced.

Samples shall be made from the same material as that used to produce the castings which they represent. The same melt and heat treatment processes shall be applied.

Several types of samples (separately cast samples, cast-on samples, side-by-side cast samples, samples cut from a casting) can be used, depending on the mass and wall thickness of the casting (see Table 3).

When appropriate, the type of sample should be agreed between the manufacturer and the purchaser. Unless otherwise agreed, the choice of the option is left to the discretion of the manufacturer.

When the mass of the casting exceeds 2 000 kg and its relevant wall thickness exceeds 60 mm, cast-on samples or side-by-side cast samples should be preferably used. Representative dimensions and the location of the sample shall be agreed between the manufacturer and the purchaser at the time of acceptance of the order.

If the spheroidizing treatment is carried out in the mould (in-mould process), the separately cast sample should be avoided.

All samples shall be adequately marked to guarantee full traceability to the castings which they represent.

The samples shall be subject to the same heat treatment as that of the castings they represent. Tensile and impact test pieces shall be finally machined from the samples after the heat treatment.

8.2 Cast samples

8.2.1 Size of cast samples

The size of the sample shall be in correspondence with the relevant wall thickness of the casting as shown in Table 3.

If other sizes are used, this shall be agreed between the manufacturer and the purchaser.

Table 3 — Types and sizes of cast samples and sizes of tensile test pieces in relation to relevant wall thickness of the casting

Dimensions in millimetres

Relevant wall thickness t mm	Type of cast sample Option 1 U-shaped (see Figure 1)	Option 2 Y-shaped (see Figure 2)	Option 3 Round bar shaped (see Figure 3)	Cast-on sample (see Figure 4)	Preferred diameter of tensile test piece[a] d mm
$t \leq 12{,}5$		I	Types b, c	A	7 (Option 3: 14 mm)
$12{,}5 < t \leq 30$		II	Types a, b, c	B	14
$30 < t \leq 60$	[b]	III	—	C	14
$60 < t \leq 200$		IV	—	D	14

[a] Other diameters, in accordance with Figure 5, may be agreed between the manufacturer and the purchaser.

[b] The cooling rate of this cast sample corresponds to that of a 40 mm wall thickness.

8.2.2 Frequency and number of tests

Samples representative of the material shall be produced at a frequency in accordance with the in-process quality assurance procedures adopted by the manufacturer or as agreed with the purchaser.

In the absence of an in-process quality assurance procedure or any other agreement between the manufacturer and the purchaser, a minimum of one cast sample for the tensile test shall be produced to confirm the material grade, at a frequency to be agreed between the manufacturer and the purchaser.

When impact tests are required, samples shall be produced at a frequency to be agreed between the manufacturer and the purchaser.